Break up of droplets in time-dependent flow

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Introduction

Properties of blends depend largely on the micro-structure, which is the result of break up and coalescence during processing. The objective of the present study is to determine the effect of time-dependent flow conditions and visco-elastic behavior on the deformation and break up of droplets.

Experimental Methods

A single Newtonian or visco-elastic droplet is subjected to a Newtonian hyperbolic flow, using an opposed jets device, as shown in figure 1.

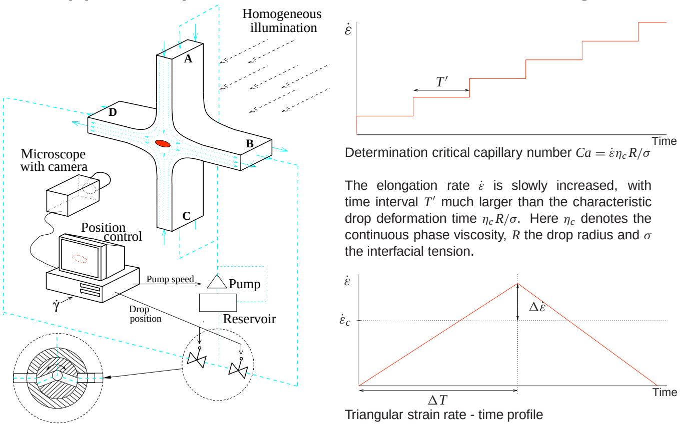

fig. 1 *Experimental setup and strain rate profiles applied*

In quasi steady flow, the critical capillary number is determined, which defines the critical elongation rate $\dot{\varepsilon}_c$ at which a stable drop shape no longer exists. To study the droplet behavior in a more realistic flow, a triangular strain rate - time profile is applied, varying the rheological properties of the phases as well as the parameters ΔT and $\Delta\dot{\varepsilon}$ (see figure 1).

Results

Experiments have been performed using a visco-elastic drop (R=1.23 mm, 1.65 wt% PEO 5e6 in H_2O) dispersed in silicon oil (η_c =10 Pa·s), which has a critical deformation $D_c \approx$ 0.35 (figure 2).

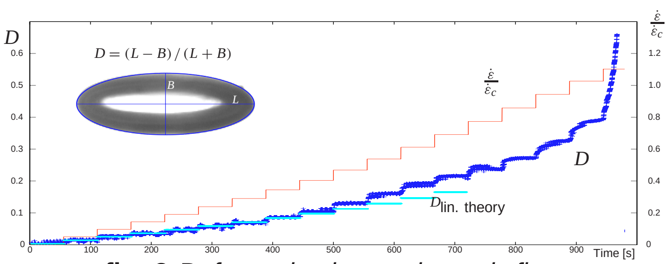

fig. 2 *Deformation in quasi steady flow*

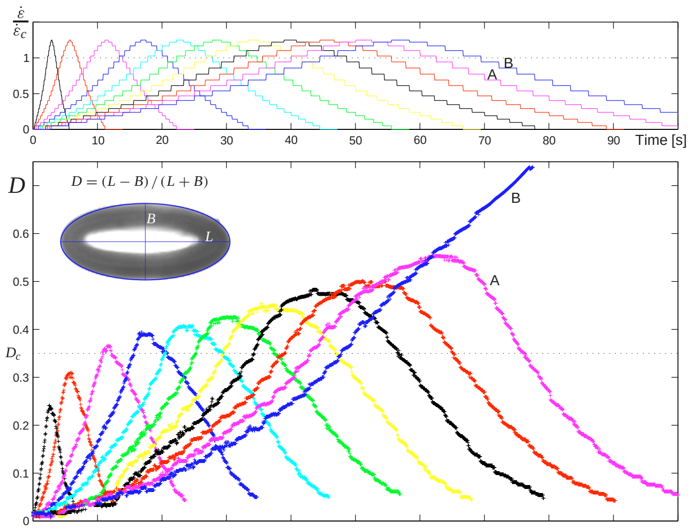

fig. 3 *Droplet deformation, applying a triangular strain rate profile with $\Delta\dot{\varepsilon} = 0.25\dot{\varepsilon}_c$ and ΔT=2.7, 5.6, 11, 17, 22, 28, 33, 39, 44, 50, and 56 s.*

Applying triangular strain rate - time profiles with $\Delta\dot{\varepsilon} = 0.25\ \dot{\varepsilon}_c$ and various ΔT, it is found that at small ΔT, the droplet can not respond fast enough to reach this deformation D_c, see figure 3. As ΔT is increased, the droplet reaches more elongated shapes with $D > D_c$, though break up does not occur. As is shown in figure 4, the drop will break up if ΔT exceeds a critical value.

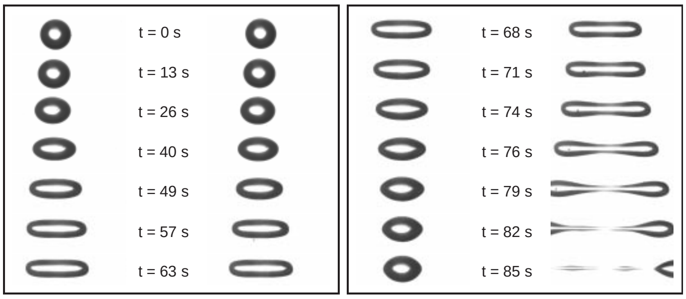

fig. 4 *Droplet response to the triangular strain rate - time profiles A (left, ΔT=50 s) and B(right, ΔT=56 s) of figure 3*

Future Work

- Experimental examination of:
  - the influence of visco-elasticity
  - the critical values of parameters ΔT, $\Delta\dot{\varepsilon}$
- Numerical analysis of the response of a droplet to time-dependent strain rate profiles

Acknowledgements

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